OFFSHORE WIND ACCELERATOR
PROJECT WEBINAR SERIES

Making the Economic Case for Offshore Wind:

"OSW Learning Investment Study" by The Brattle Group
Stakeholder Briefing

March 11, 2013

OffshoreWind Accelerator Project
Managed by Clean Energy States Alliance

CleanEnergy States Alliance

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This webinar is being recorded and will be made available after the call at **www.cleanenergystates.org** under **Events**. Previous webinar recordings are also posted.

Today's Agenda

- Presentation by Dr. Jurgen Weiss, The Brattle Group
- Time for questions

Please Submit Questions

Questions submitted from webinar participants will be addressed following the presentation. Please type your questions in the webinar console's Question box at any time during the broadcast.

Clean Energy States Alliance

CESA is a non-profit organization working with states, federal agencies, and municipalities to advance the renewable energy sector through:

- Information Exchange & Analysis
- Partnership Development
- Networking and Collaboration

www.cleanenergystates.org

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Stay connected to OWAP!

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Offshore Wind Accelerator Project

OWAP Objective: Address key challenges facing offshore wind in five focus areas

1. Ensure cooperation and communication among stakeholders and government leaders on priority problem-solving.
2. Improve regulatory approaches to support smart siting while reducing review costs & timelines.
3. Advance investment through power procurement collaborative networks and use of new financing mechanisms.
4. Advance opportunities, strategies, and collaboration to build a domestic OSW industry **(USOWC leads the supply chain effort).**
5. Implement a communication effort to ensure public education and stakeholder access to objective information.

Upcoming OWAP Webinar

- **March 19**: "Understanding Regional Offshore Wind Supply Chain Opportunities"

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Thank you!

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The Brattle Group

A Learning Investment-based Analysis of the Economic Potential for Offshore Wind:

The case of the United States

A study prepared for
Center for American Progress
Clean Energy States Alliance
The Sierra Club
US Offshore Wind Collaborative

Presented by:
Jurgen Weiss

March 11, 2013

1 Minute on myself

- Principal, The Brattle Group
- Energy Economist with emphasis on issues motivated by climate change
- PhD Business Economics, Harvard and MBA, Columbia
- Have consulted and written on offshore wind issues (expert witness for the MA AG in Cape Wind case)
- The Brattle Group is an economic consulting firm with 200 professionals in the USA and Europe.

Key questions to be addressed in this webinar

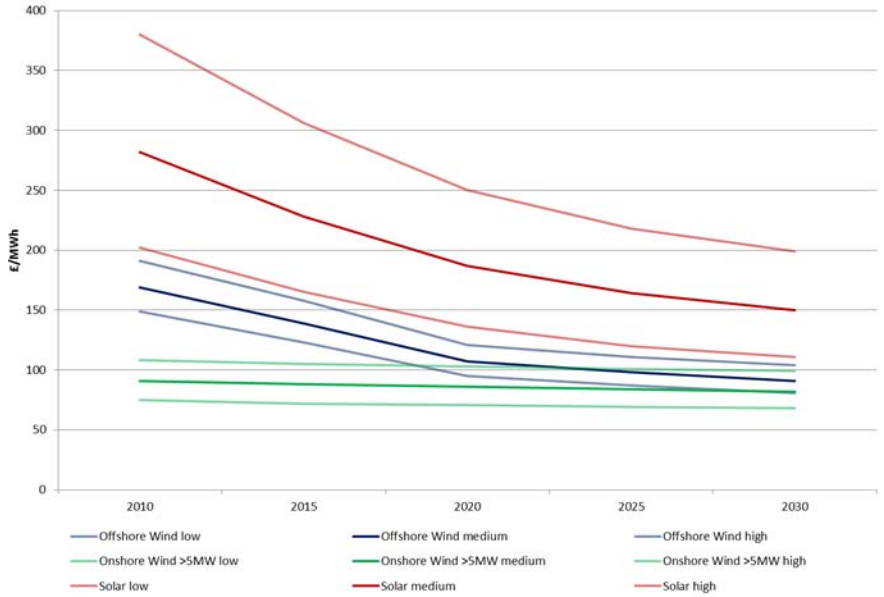
We were asked to assess the economic impact of investing in the scaling of offshore wind with the goal of bringing it to grid parity.

- Basic framework for analyzing the economics of offshore wind
- What do we know/What can we expect
- Implications for the potential of offshore wind in the US
- Conclusions

From today's perspective, it is hard to tell whether any one renewable technology will "win"…

- As the picture, shows, multiple renewable technologies converge
- Large bands around "mean estimates" suggest that there is no clear winner
- It therefore makes sense to invest and observe how much learning lowers costs
  - For offshore wind
  - Likely for some other technologies as well

Estimated LCOE for Renewable Technologies in the U.K.



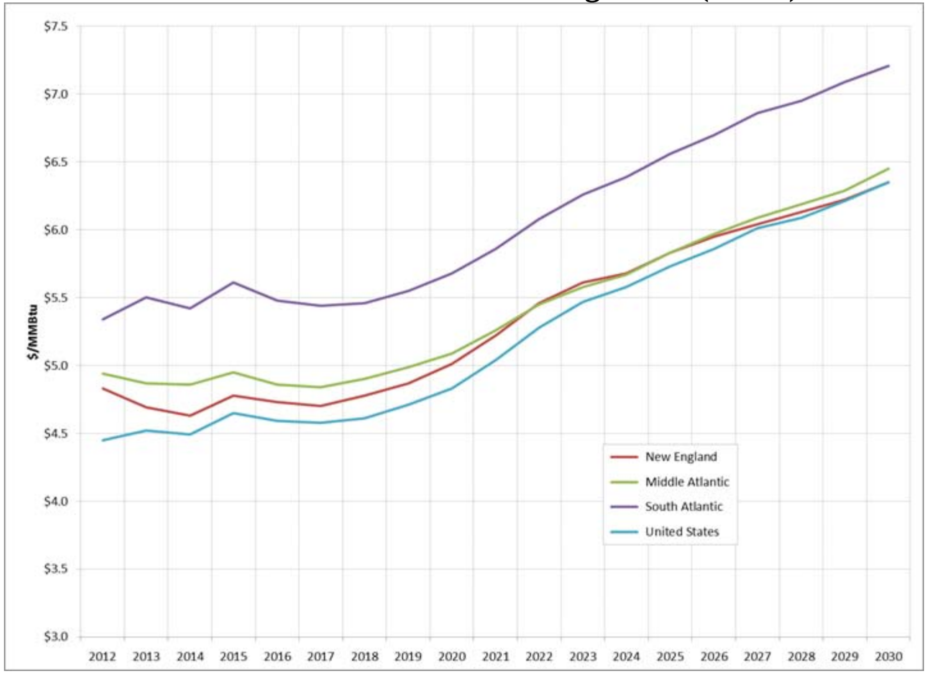
Source: DB Climate Change Advisors, "U.K. Offshore Wind: Opportunity, Cost & Financing," Exhibit 14.

Question: How much does it cost to make these "investments"?

…Or whether gas prices will stay at their historic lows.

- Renewables are competing with market prices driven by natural gas (US)
- Gas prices are at historic lows
- Historically, gas prices have been volatile and likely to increase substantially again.
- In addition to providing greenhouse gas reduction benefits, OSW serves as an important hedge against the risk of high(er) future gas prices

Forecast Natural Gas Prices through 2030 ($2010)

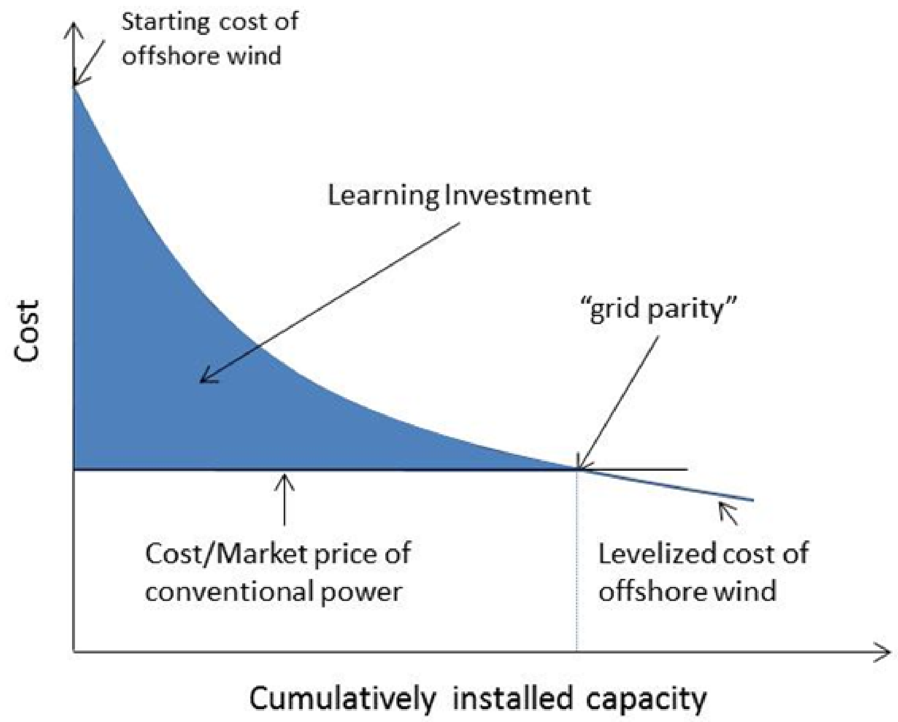


Source: EIA, Annual Energy Outlook 2012, Early Release

Question: What is the “cost” of this hedge?

It may therefore make sense to investment in the scale up of newer technologies such as OSW.

- As technologies mature and scale up, costs decline
- We used a relatively simple framework to calculate the cost of the "learning investment"
  - Various starting point cost assumptions for OSW
  - Various learning rates
  - Two market benchmarks
    - Without CO2
    - With CO2



Learning rate = % reduction in cost for each doubling of cumulatively deployed capacity

Learning rates for offshore wind are expected to be between 3% and perhaps as high as 10%

- Various studies have estimated the "corrected" learning path based on engineering/bottom-up analysis
- Also, experience with onshore wind, PV etc. provides useful historic comparisons
- All said, learning rates of 3% to 10% seem reasonable.

Scenario	Description	Implied Learning Rate*
Slow Progression	• 31GW in Europe by 2020 (12GW in UK) • Incremental technology evolution, progress limited by market size • Limited completion /economies of scale • Modest developments in financing solutions, reduced in risk/cost of capital	4.4%
Technology Acceleration	• 36GW in Europe by 2020 (17GW in UK) • High levels of technology evolution across all wind farm • elements (e.g. turbines progress rapidly to 5-7MW+) • Fragmented supply chain with some improvement in collaboration • Limited improvement in cost of capital due to ongoing changes in technology	7.1%
Supply Chain Efficiency	• 36GW in Europe by 2020 (17GW in UK) • Incremental technology evolution (e.g. steady progress to 5-7MW turbines) • Greater competition, investment, project collaboration and better risk management • Deeper financial markets, lower risk/lower cost of capital	7.9%
Rapid Growth	• 43GW in Europe by 2020 (23GW in UK) • High levels of technology evolution across all wind • farm elements (e.g. turbines progress rapidly to 5-7MW+) • Greater competition, investment, project collaboration and better risk management • Challenging volume of finance required	8.9%

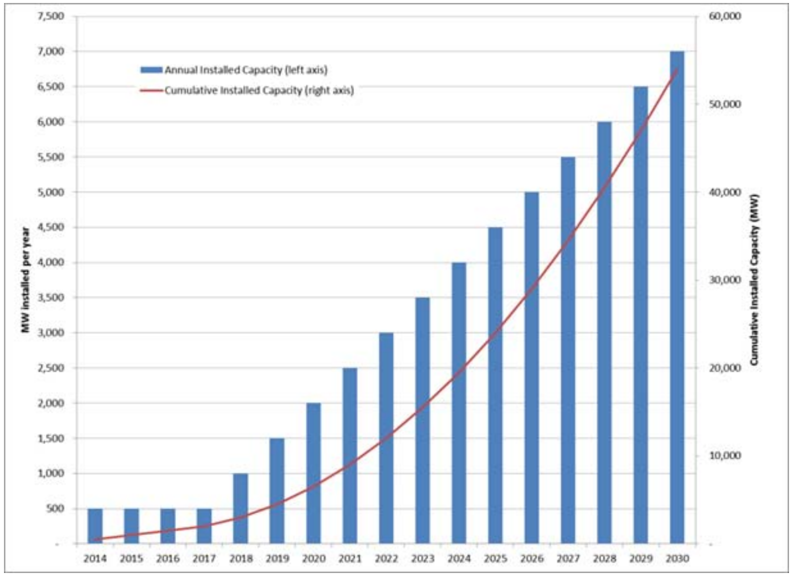
Source: The Crown Estate (2012), p.38; TBG analysis.

* To calculate the implied learning rate, we first calculated the number of doublings of total capacity under each scenario. We then used the estimated change in cost from £140/MWh today to the cost in each scenario by 2020 to derive the implicit percent change in cost for each doubling of installed capacity to achieve a particular scale.

We modeled three different OSW cost paths to capture the range of potential cost trajectories.

- Designed to cover the range of likely cost trajectories
  - Slow: 3% learning rate with a starting point cost of \$300/MWh, similar to proposed U.S. pilot projects
  - Medium: 5% learning rate with a starting point of \$231/MWh, based on most recent DOE estimates for US
  - Fast: 10% learning rate with a starting point of \$200/MWh, slightly below the most recent projections for Europe.
- Use 54 GW of offshore wind deployed through 2030
  - One case examined by DOE
  - Kept constant across the three cases to test how cost would differ in 2030 due to learning in all three cases

Assumed U.S. Offshore Wind Development Path



Scenario	Offshore Wind Learning Rate	2014 LCOE (OSW)	2014 LCOE (Market without CO_2)	2014 LCOE (Market w/CO_2) *	2030 LCOE (OSW)	2030 LCOE (Market without CO_2)	2030 LCOE (Market w/CO_2) *
	%	*\$2012/ MWh*	*\$2012/ MWh*	*\$2012/ MWh*	*\$2012/ MWh*	*\$2012/ MWh*	*\$2012/ MWh*
Slow	3%	\$300	\$66.82	\$75.11	\$186	\$76.27	\$137.96
Medium	5%	\$231	\$66.82	\$75.11	\$138	\$76.27	\$137.96
Fast	10%	\$200	\$66.82	\$75.11	\$98	\$76.27	\$137.96

Reaching "Grid Parity" depends on offshore wind costs and learning and market/social cost of alternative.

Two Grid-parity benchmarks:

- **Market Grid-parity:** Cost of CCGT, including current (small) subsidies for gas, no CO_2 price in power price
- **CO_2-Grid parity**: Same, but include the avoided GHG cost assuming a gradually increasing CO_2 price (start at $10, go to $100 by 2030) and coal/gas mix (declining from 30% coal to 10% coal)

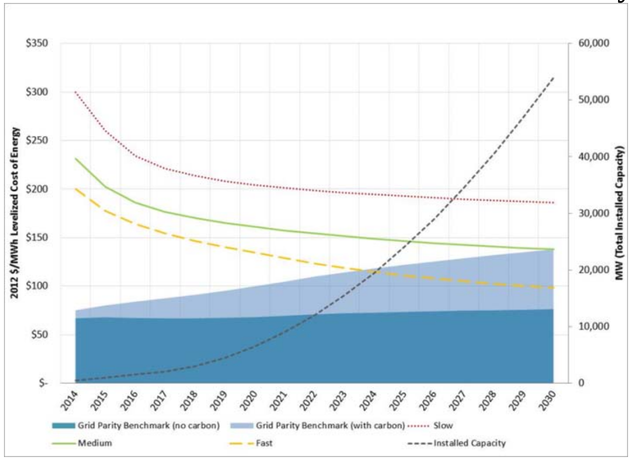
Can get to CO_2 grid parity by 2030 under medium/fast paths.

If other coal externalities are included in the analysis, would reach CO_2 grid parity much faster.

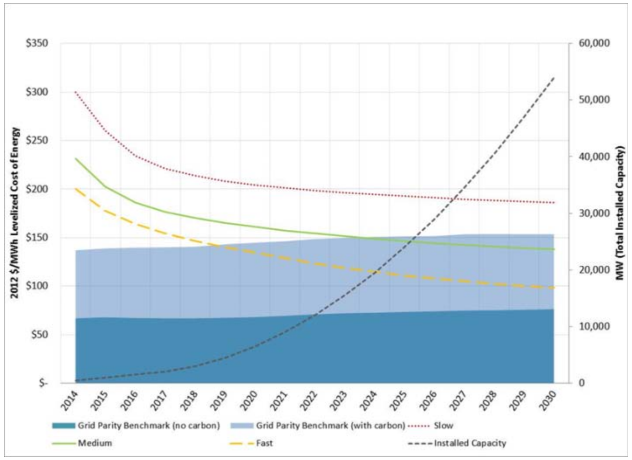
Important to note:

- Analysis assumes no federal tax credits or accelerated depreciation available to offshore wind
- If these federal incentives are in place, OSW would reach grid parity even sooner
- CO_2 grid parity is a reasonable benchmark as it highly likely that there will be additional state or federal legislative action on carbon emissions between now and 2030
- If slow learning path occurs, public investment in OSW would be discontinued as matter of smart public policy
- OSW grid parity could occur sooner than analysis indicates with technology advances such as floating platforms and/or with lower financing costs as investment risks decline

Offshore Wind Path to Potential Grid Parity



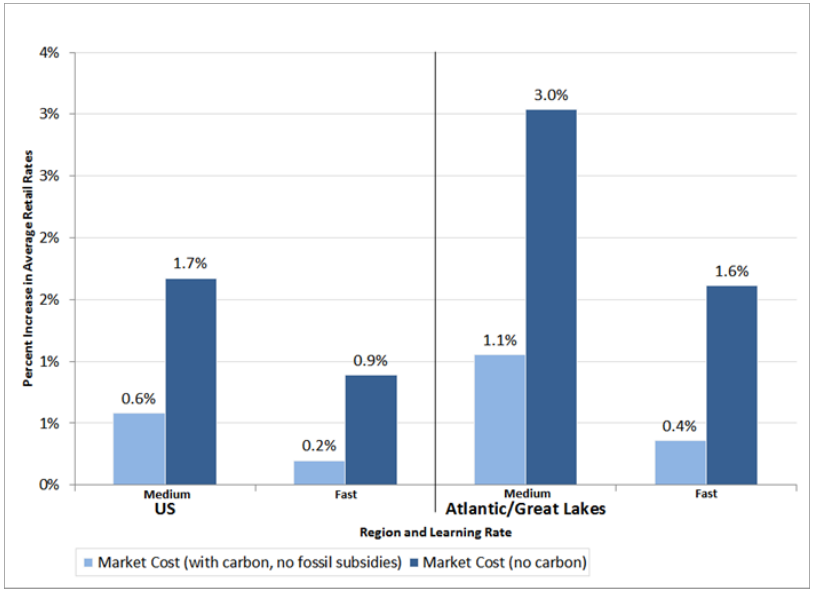
Offshore Wind Path to Potential Grid Parity with coal externalities



The rate impacts of scaling offshore wind are very small.

- The total learning investment is between $18 and $52 billion.
- This is comparable to the support to a mix of other energy sources in the past (fossil fuels, nuclear)
- OSW learning investment would have very moderate impacts on retail rates
- Actual rate/bill impacts depend on
  - how broadly the investment is financed (US v. regionally)
  - How fast learning is
  - Whether CO_2 is included in the benchmark
- If investment spread across all US electricity sales, average monthly bill increase from $0.25 (w/carbon, fast learning) to $2.08 (no carbon, medium learning)

Impact of offshore wind scaling on average retail rates between 2014 and 2030



Grid Parity Benchmark	Learning Scenario	Total Learning Investment 2014-2030 (2012$ billion)	Rate Impact (2012 c/kWh)	Rate Impact % Rate Increase	Avg. Monthly Bill Impact $/month
Market Cost (no carbon)	Medium	$ 149.6	$ 0.22	1.7%	$ 2.08
	Fast	$ 79.4	$ 0.12	0.9%	$ 1.10
Market Cost (with carbon, no gas subsidy)	Medium	$ 51.9	$ 0.08	0.6%	$ 0.72
	Fast	$ 17.7	$ 0.03	0.2%	$ 0.25

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Since energy is currently "cheap" and since we have made similar investments in the past, OSW learning investment likely makes sense as part of a national energy portfolio.

- Putting the offshore wind learning investment ($18 -150 billion) in perspective.
- Household expenditure shares are the lowest they have been in half a century.
- We have made similar investments in other energy technologies over the last 60 years
  - Nuclear: $73 billion
  - Natural Gas: $121 billion
  - Coal: $104 billion
- Compare economic cost of a single bad weather event: Hurricane Sandy at $50 billion.
- Given the huge uncertainties about gas prices, climate issues, and the progress (cost and deployment) of other renewables, creating another egg for the basket of options likely makes sense
- OSW is well positioned to lead to net economic gains due to its local content.

Share of electricity/natural gas in total household consumption expenditure

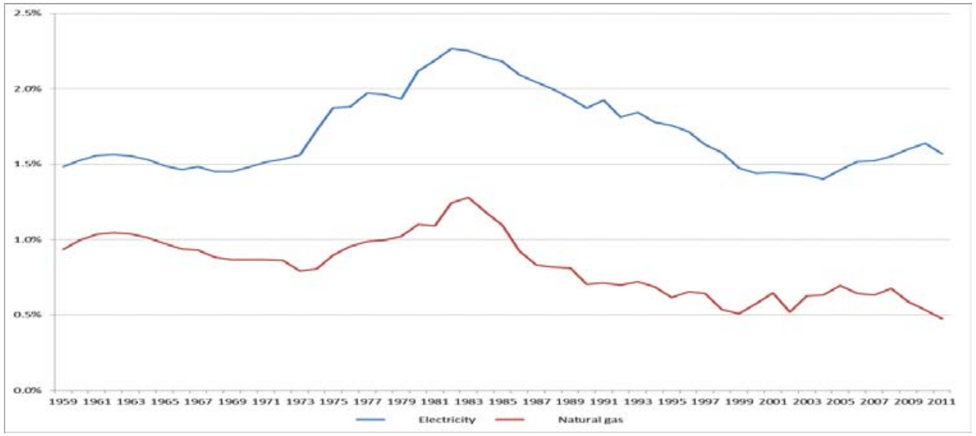

Exhibit 1 – Summary of Federal Energy Incentives, 1950–2010

(Billions of 2010 Dollars[1])

TYPE OF INCENTIVE	ENERGY SOURCE							SUMMARY	
	Oil	Natural Gas	Coal	Hydro	Nuclear	Renewables[2]	Geothermal	Total	Share
Tax Policy	194	106	35	13	-	44	2	394	47%
Regulation	125	4	8	5	16	-	-	158	19%
R&D	8	7	36	2	74	24	4	153	18%
Market Activity	6	2	3	66	-	2	2	80	10%
Gov't Services	34	2	16	2	2	2	-	57	7%
Disbursements	1	-	7	2	-18	2	-	-6	-1%
Total	369	121	104	90	73	74	7	837	
Share	44%	14%	12%	11%	9%	9%	1%		100%

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Thank-you

For questions or comments, please contact

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